US Army Corps
of Engineers ®
Mobile District

Using GIS as a Tool for Spatial Analysis: Developing a Regional Sediment Budget

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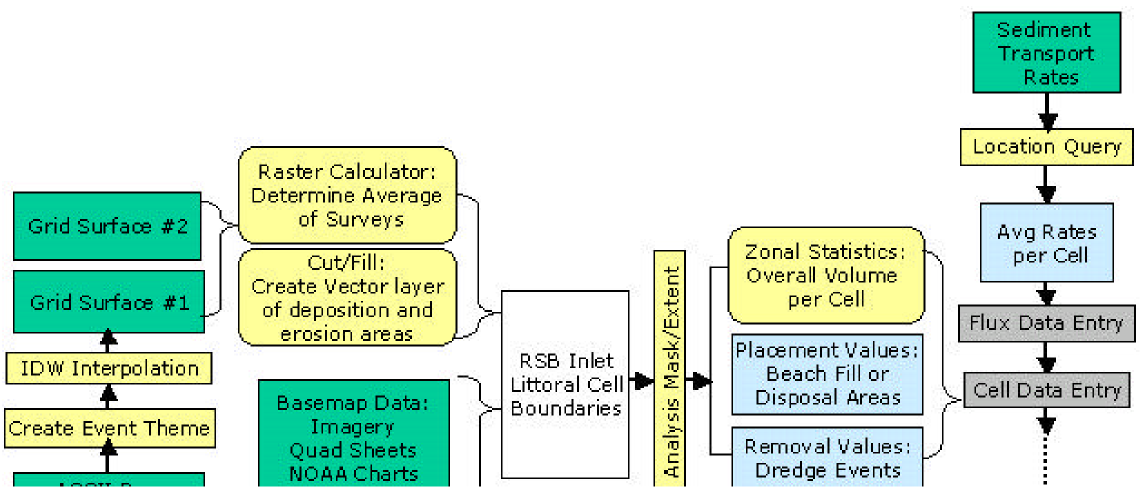
PURPOSE:
A comprehensive Geographic Information System (GIS) enables its users organize, develop and maintain various types of coastal data and resources. GIS provides the tools necessary for spatial data analysis. The purpose of this tutorial is to instruct all levels of GIS users on the processes needed to compute values for a sediment budget in the ArcGIS 8.x environment.

GETTING STARTED:
All data analysis will be done with ESRI's ArcMap for ArcGIS 8.x. Additional extensions, such as Spatial Analyst, 3D Analyst and Xtools, will also be incorporated in this tutorial.

OVERVIEW PROCESS:

Flow Chart Key

Green:	GIS Data
Yellow:	GIS Process
Blue:	Calculated Value
White:	Sediment Budget Components



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Preprocessing Coastal Data

Importing ASCII Raw Data

How ArcGIS Reads Text Files

When you add a delimited text file to your project ArcView displays it in a table by placing the text following each tab or comma in a separate cell for each line in the file. The first line in the text file is expected to be the field names for the table. Fields with values containing any characters that are not numbers are treated as strings. Fields with values containing only numbers are treated as numeric fields. Strings can either be quoted or unquoted. (If you want ArcGIS to read numeric values in as strings, enclose the numbers in quotes).

Here's an example of a comma-delimited text file that can be read into ArcGIS as a table with four fields, one of which is numeric, and five records:

```
City,Country,Annual sales,Sales person
London,England,45000,Rupert
Paris,France,32900,Maurice
Madrid,Spain,110000,Manuel
Lisbon,Portugal,34000,Cynthia
Glasgow,Scotland,15000,Robbie
```

Converting Raw Data into a Comma-Delimited file

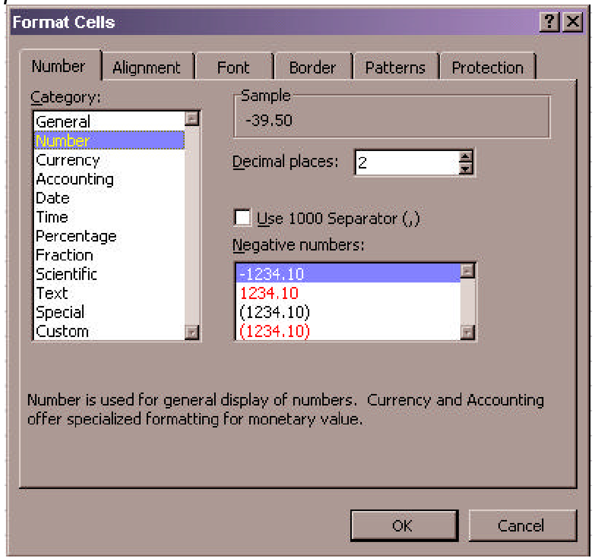
In a Text Editor:

1. Open the text file.
2. Insert a new line at the top of the file.
3. Type in the header row information, e.g., Easting, Northing, Elevation
   *No spaces between the commas.
4. Now, separate the rest of the data into comma-delimited columns
5. Manually type in the commas to divided each column; **OR** use the Replace option to find a space (or number of spaces) and replace with a comma.
6. Save as a text, *.txt, file.

Before	After
2036089.350 10932282.070 -39.500 2036078.020 10932301.350 -39.570 2036083.760 10932321.480 -40.060 2036106.320 10932221.750 -40.220 2036107.130 10932246.710 -40.520	Easting,Northing,Elevation 2036089.350,10932282.070,-39.500 2036078.020,10932301.350,-39.570 2036083.760,10932321.480,-40.060 2036106.320,10932221.750,-40.220 2036107.130,10932246.710,-40.520

In Excel:

powerful text editor or Access.



In Access:

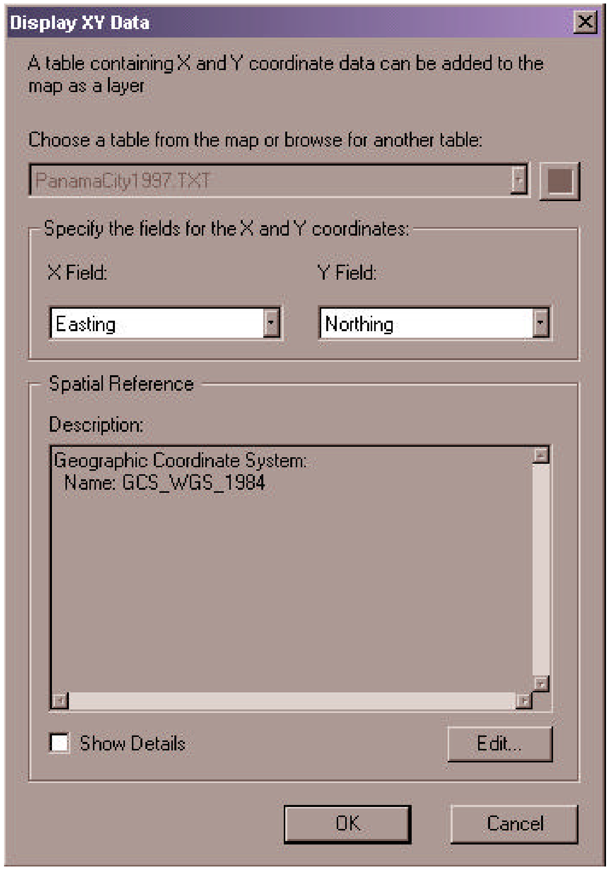
1. Open a database, or switch to the Database window for the open database.
2. To import data, on the File menu, point to Get External Data, and then click Import.
3. In the Import dialog box, in the Files Of Type box, select Text Files.
4. Click the arrow to the right of the Look In box, select the drive and folder where the file is located, and then double-click its icon.
5. Follow the directions in the Import Text Wizard dialog boxes.
6. Select "Fixed Width" if columns are separated by spaces. Select "Delimited" if tabs separate columns.
7. Edit the field names so they represent your header information, e.eg,, Easting, Northing, Elevation
8. When finished importing the table, right-click on this table, select "Save As/Export" and save as a *.dbf file.

NOTE: *Spaces, periods and other non-alphanumeric characters in file or directory names may cause problems. Underscores are the only non-alphanumeric characters that should be used. It is also recommended that you follow an 8.3 naming convention.*

Convert Comma-Delimited file into GIS Layer

1. To create a point file, Add in the comma-delimited table (*.txt, *.dbf) in the ArcMap layer.
2. Right-click on imported table and select ***Display XY Data***.
3. Specify fields to use for X and Y columns using the respective drop-down lists.

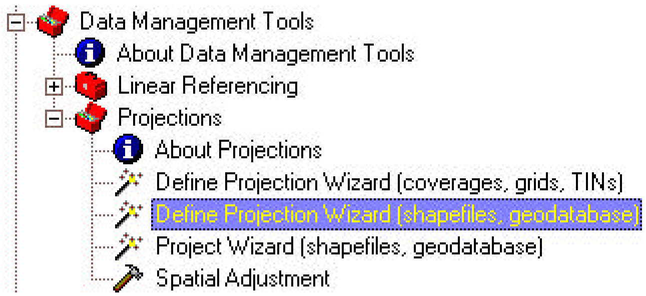
X	Longitude	East/West – remember negative values for West
Y	Latitude	North/South – remember negative value for South
If using a geographic coordinate system, for values to plot properly, values must be in decimal degrees, not degrees/minutes/seconds.		



4. Clicking on the ***Edit*** button enables a coordinate system to be chosen.
5. To display the data in a standard coordinate system click on the ***Select*** button which will provide options.
6. The ***Import*** and ***New*** options are also available for setting the coordinate system.
7. After the coordinate system is selected click ***OK*** twice.
8. ArcMap then builds a point theme for the XY points.
9. To convert this temporary layer into a shapefile, right-click on the newly created layer and select ***Data*** from the drop-down menu. From the second drop-down box select ***Export Data***. Browse and save the file in the desired directory.

Projection Utility

In order for data sets to line up, all layers must be defined and projected into the same



Once the projection has been defined, the layer is now ready to be projected using ***the Project Wizard***. Follow the onscreen instructions to input the original projection information and desired coordinate system. The Project Wizard will create a new layer with the newly defined projection.

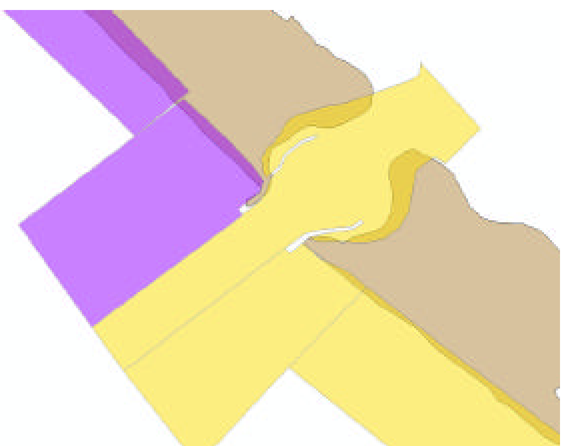
Regional Sediment Budget: The Littoral Cell

Creating Littoral Cell Boundaries

Littoral cells are defined by a collection of information describing similar physical, biological, and cultural characteristics within a particular area. The littoral cell inventory information can be in the form a map, database and text formats.

Using the ***Drawing Tools*** in ArcMap, graphic polygons can be drawn to represent cells areas. The boundaries of the littoral cells can be defined by either morphological features, such as, ebb and flood shoals, inlet throat, and adjacent beaches or political boundaries, such as, nautical charts and municipal boundaries for reference.

Using the ***Draw Rectangle*** and ***Draw Polygon*** tools, littoral cells can be placed in data frame. To draw simple, rectangular cells, select the ***Draw Rectangle*** tool and click where the upper right boundary of the littoral cell should reside; then drag to the lower right boundary. When the mouse button is released, a rectangle will be displayed in the frame. To draw irregular shaped cells, select the ***Draw Polygon*** tool and click to represent each vertices of the polygon. Double-click to finish drawing the cell.



Littoral Cells for the Panama City Inlet

*If using the SBAS-A extension, please follow the technical note that outlines how to create littoral cell layers.

Creating Grid Surfaces

Grid Surfaces will be used to compute the average volume per each littoral cell. For each bathymetric survey, create a grid surface.

Creating Barrier Polyline

Barrier polylines are used to define the extents of a grid.

1. If not loaded already, load the ***XTools*** (download from ESRI's support sire if necessary) extension for ArcMap 8.
2. Start out by creating a polyline around the outside points of the shapefile.
3. If you dataset has "holes", or no data areas, also draw a polygon around these areas.
4. Select polygon sets of main polygon and null data areas. For each selected set, from the Drawing Menu, select ***Graphic Operations, Remove Overlap***. This will "cut" a hole where the null data area resides.
5. If you have more than one polygon, group all of the graphics together. Select all of the graphics, and from the ***Drawing Menu***, select ***Graphic Operations***, ***Union***.
6. Click on the XTools Menu and select convert shapefile to graphics. Use this clip polygon shapefile for creating a Grids and TINs.

Grid Interpolation

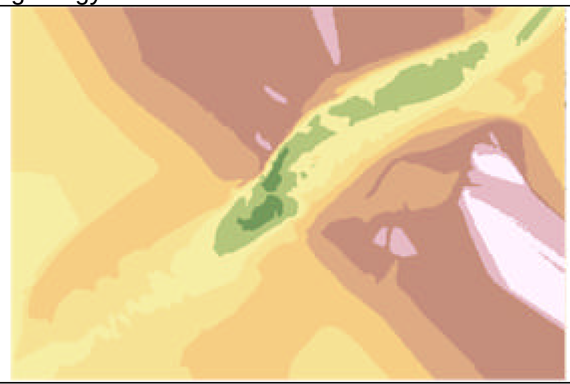
**In order to create a Grid Surface, the Spatial Analyst Extension to ArcGIS 8.x is required.*

1. Click the ***Spatial Analyst*** dropdown arrow, point to ***Interpolate to Raster***, and select interpolation method – Inverse Distance Weighted, Spline, or Kriging.
2. Click the ***Input features*** drop-down arrow and click the feature to be converted to a raster.
3. Click the ***Field*** dropdown arrow and click the field that will be copied to the Output raster.
4. Optionally, type an Output cell size.
5. Specify a name for the output raster or leave the default to create a temporary dataset in the working directory.

Interpolation Methods:

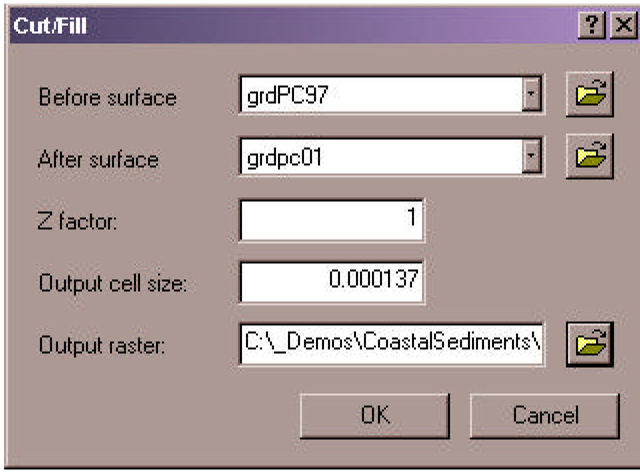
The Inverse Distance Weighted (**IDW**) and **Spline** methods are referred to as deterministic interpolation methods because they are directly based on the surrounding measured values or on specified mathematical formulas that determine the smoothness of the resulting surface. A second family of interpolation methods consists of geostatistical methods (such as **kriging**), which are based on statistical models that include autocorrelation (the statistical relationship among the measured points). Because of this, not only do these techniques have the capability of producing a prediction surface, but they can also provide some measure of the certainty or accuracy of the predictions.

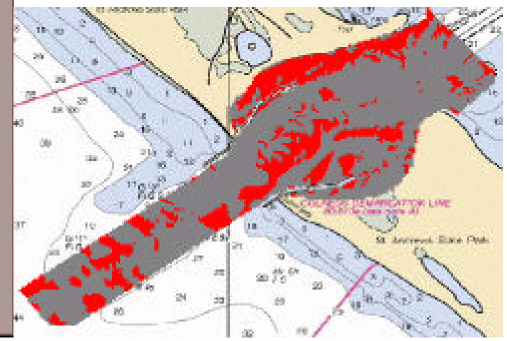
Inverse Distance Weighted	IDW estimates cell values by averaging the values of sample data

Spline	Spline estimates values using a mathematical function that minimizes overall surface curvature, resulting in a smooth surface that passes exactly through the input points. Conceptually, it is like bending a sheet of rubber to pass through the points while minimizing the total curvature of the surface. It fits a mathematical function to a specified number of nearest input points while passing through the sample points. This method is best for gently varying surfaces such as elevation, water table heights, or pollution concentrations.
Kriging	This interpolation method assumes that the distance or direction between sample points reflects a spatial correlation that can be used to explain variation in the surface. Kriging fits a mathematical function to a specified number of points, or all points within a specified radius, to determine the output value for each location. Kriging is a multistep process; it includes exploratory statistical analysis of the data, variogram modeling, creating the surface, and (optionally) exploring a variance surface. This function is most appropriate when you know there is a spatially correlated distance or directional bias in the data. It is often used in soil science and geology.
IDW Grid Surface -55.91293335 - -43.39568668 -43.39568667 - -30.87844001 -30.87844 - -18.36119334 -18.36119333 - -5.843946669 -5.843946668 - 6.673300001 6.673300002 - 19.19054667 19.19054668 - 31.70779334 31.70779335 - 44.22504001 44.22504002 - 56.74228668	

Using Cut/Fill to Analyze Sediment Deposition and Erosion

Cut/Fill summarizes the areas and volumes of change between two surfaces. It identifies the areas and volume of the surface that have been modified by the addition or removal of surface material.
By taking two surface rasters of a given area from two different time periods, the Cut/Fill function will produce a raster displaying regions of surface material addition, surface material removal, and areas where the surface has not changed over the time period. Negative volume values indicate areas that have been filled, positive volume values indicate regions that have been cut.





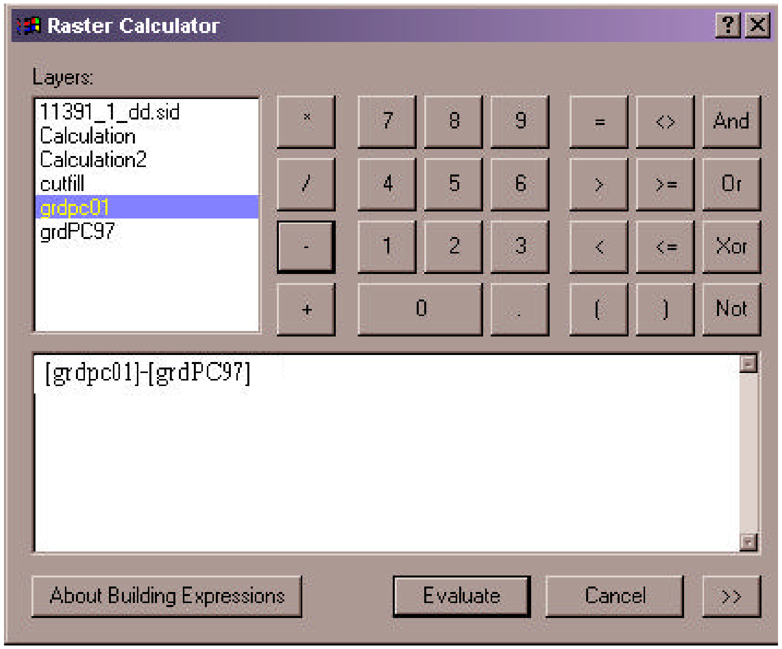
Using the Raster Calculator to Create the Volume Difference per Littoral Cell

The Raster Calculator provides you with a powerful tool for performing multiple tasks. You can perform mathematical calculations using operators and functions, set up selection queries, or type in Map Algebra syntax. Inputs can be raster datasets or raster layers, coverages, shapefiles, tables, constants, and numbers. When creating a Regional Sediment Budget, we will use the ***Raster Calculator*** to create a new surface that represents an average of the surveys.

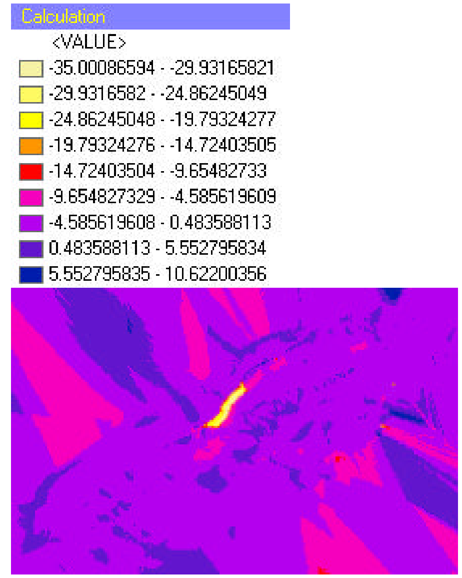
Arithmetic operators allow for the addition, subtraction, multiplication, and division of two rasters or numbers or a combination of the two. Arithmetic operators: ***, /, -, +**

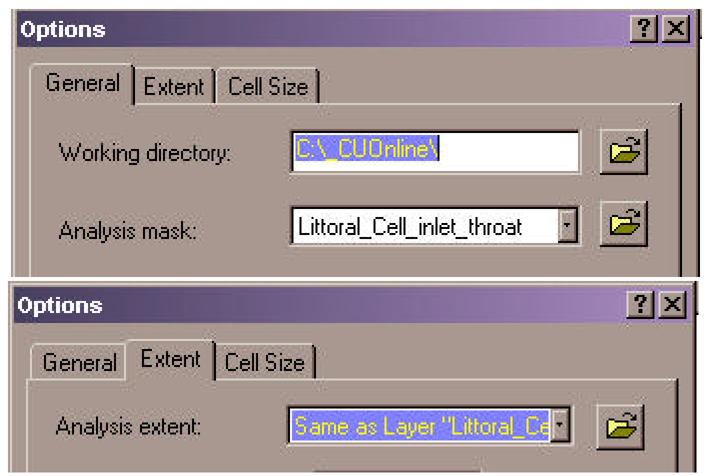
For example, the result of [2001 Survey] - [1997 Survey] results in an output grid displaying the mean value of volume change in every grid cell.

1. Click the Spatial Analyst dropdown arrow and click ***Raster Calculator***.
2. Double-click each Survey Layer to begin to build the expression.
3. Expression should read: ([2001 Survey] - [1997 Survey]), where 2001 Survey and 1997 Survey represent grid surfaces created in previous steps.
4. Click ***Evaluate*** when finished.
5. A new raster surface, Calculation, will be added to the Table of Contents.



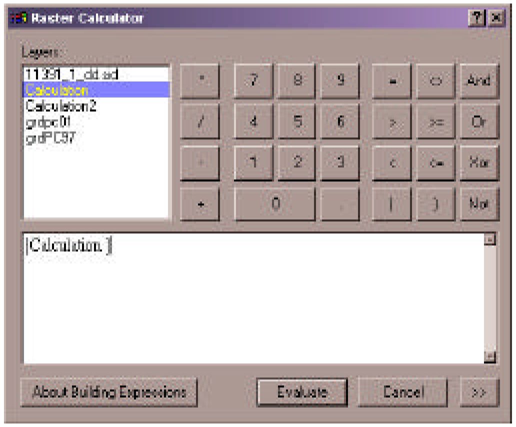
Calculation Grid:

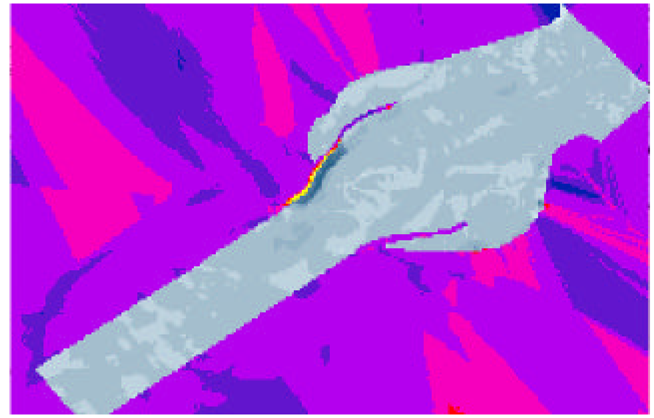




Setting the ***Analysis Mask*** and ***Analysis Extent*** of Spatial Analyst to clip the raster grid layer by an existing vector layer.

1. From the Spatial Analyst menu, select ***Options***.
2. On the ***General*** tab, set the Analysis Mask to the Littoral Cell vector layer.
3. On the ***Extent*** tab, select the Littoral Cell layer again.
4. Click OK. Nothing will change until the ***Raster Calculator*** is used.
5. Use ***Raster Calculator*** to perform clip. Double-click on the "Calculation" layer from the Layer list.
6. Click ***Evaluate.***
7. A new calculated layer is created and added to the Table of Contents.

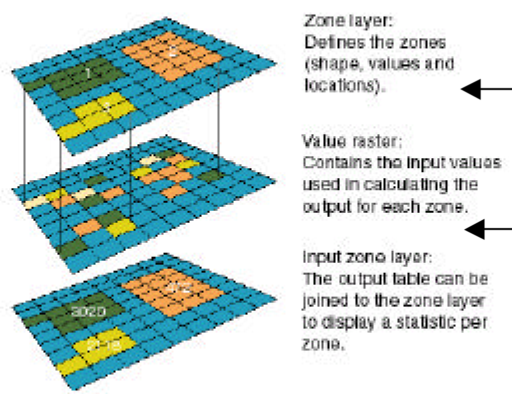




Calculating Overall Volume Difference per Littoral Cell

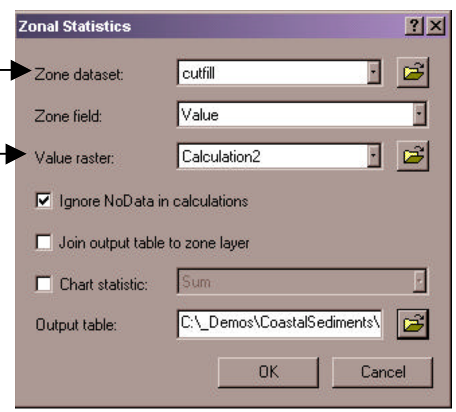
With the Zonal Statistics function, a statistic is calculated for each zone of a zone dataset based on values from another dataset. We will be designating the Cut/Fill vector layer as our input layer for calculating Zonal Statistics. From the Spatial Analyst Menu, select ***Zonal Statistics***.

1. Select Zone Dataset layer
2. Select Zone Field
3. Select Value Raster
4. Browse to location for new statistics table
5. Click OK



Use cell boundaries created by Cut/Fill.

Use raster grid representing average volume grid per Littoral Cell



6. A statistics table is created
7. To calculate total volume of littoral cell, right-click on the ***Sum*** column and select ***Statistics***

The **overall volume** for the littoral cell is listed as the ***Sum***

Littoral Cell Data Entry

Data entry into the Sediment Budget Analysis System requires a custom extension. This extension is still in its beta release, but available for download on http://gis.sam.usace.army.mil. Please reference the SBAS-A technical note located at http://chl.wes.army.mil/library/publications/chetn/pdf/chetn-xiv7.pdf for full instructions on implementing SBAS-A for your Coastal GIS environment.

1. Having an ***Alternative*** already created, littoral cell values can be entered into the data entry module.
2. Using the ***Cell/Flux Edit*** tool, select the desired littoral cell. Enter the overall volume, **dV**, that was calculated from the Zonal Statistics function in the appropriate cell.
3. Click Apply to save value changes.
4. When values are entered into this spreadsheet and the Apply button is clicked, the residual value is posted in the layer's attribute table in the Residual field.

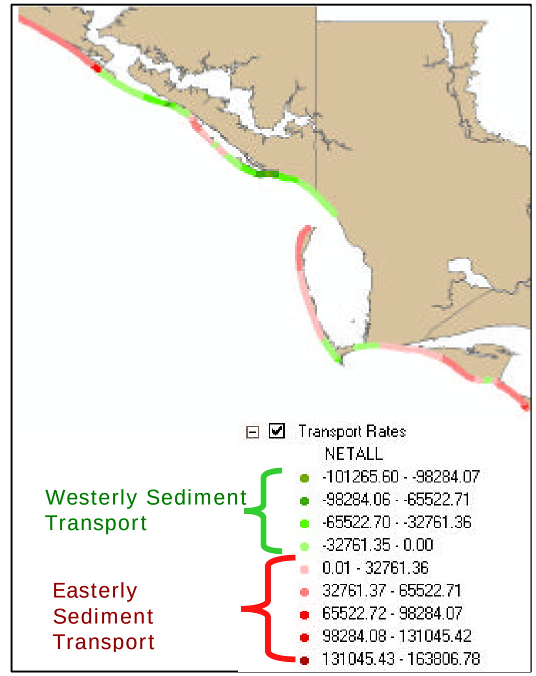
Figure A. SBAS-A Data Entry Module

Incorporating Placement and Removal Values

If man-made processes, such as dredge events or beach fills, influence littoral cell areas, these variables can be added into the sediment budget equation. Through the use of the GUI interface, (figure A) all values – dV, Placement and Removal can be entered and calculated for the cell using the SBAS-A's data entry module.

Regional Sediment Budget: Defining Flux Values

Flux values represent input and output of sediment into the cell. Each sediment budget cell requires eastward and westward transport rates. Sediment transport rates produced from GENESIS model results can be imported into GIS using the steps outlined in this document under, ***Importing ASCII Raw Data***. As a graphical representation of flux values in the GIS environment, graphic polylines can be drawn in the display and converted into shapefile.



Sediment Transport Rates from GENESIS Model

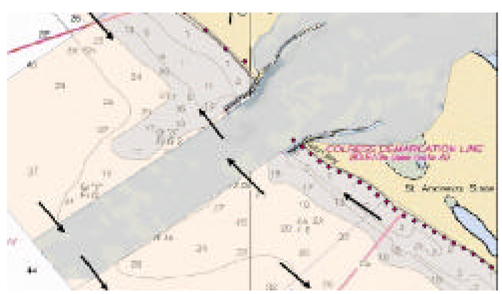
To Draw Fluxes

Flux layers are created in a similar fashion as littoral cells. To create a flux layer, the ***New Line*** tool is used . To connect two cells with a flux, using the ***New Line*** tool, click on the sink cell first and drag to the source cell. Double-click to end the line.

Flux arrows can also be drawn as polylines. Polylines allow a line to have multiple vertices to "curve" around structures. To draw a polyline, simply click to add each vertice prior to double-clicking to end the line.

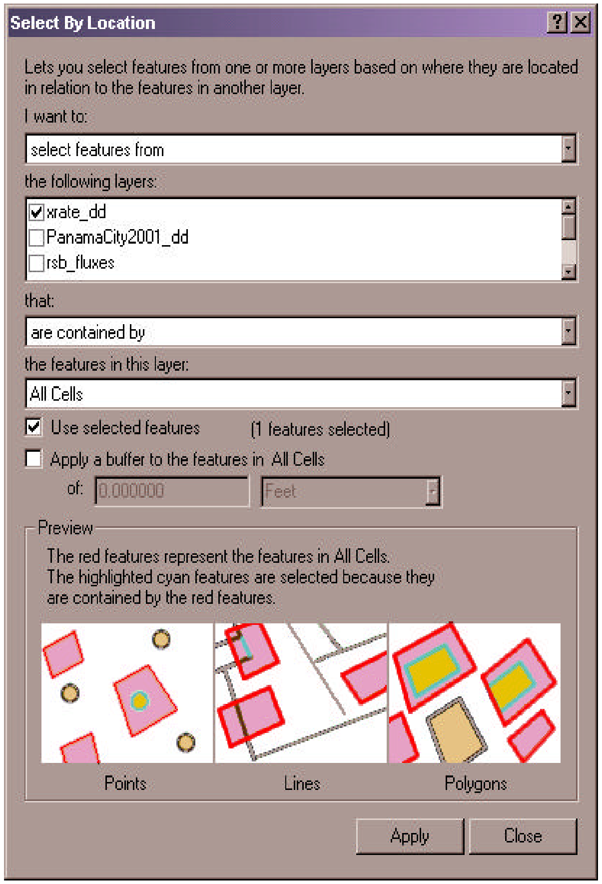
Once the graphic is drawn, covert graphics into a shapefile. To symbolize the lines as arrows:

1. Right-click on the flux layer in the Table of Contents, and select Properties
2. Click on the ***Symbology*** tab, then click on the line symbol
3. Display all Categories
4. Select ***Arrow at End***
5. Click OK twice.



First we will find all transport rates points that are contained by the littoral cell.

1. Select the desired littoral cell
2. From the Selection Menu, choose ***Select by Location***
3. Select features from ***Transport Rates*** that ***are contained by*** the ***selected*** feature in the ***Littoral Cell Layer*** (see below). Click **Apply**, then Close

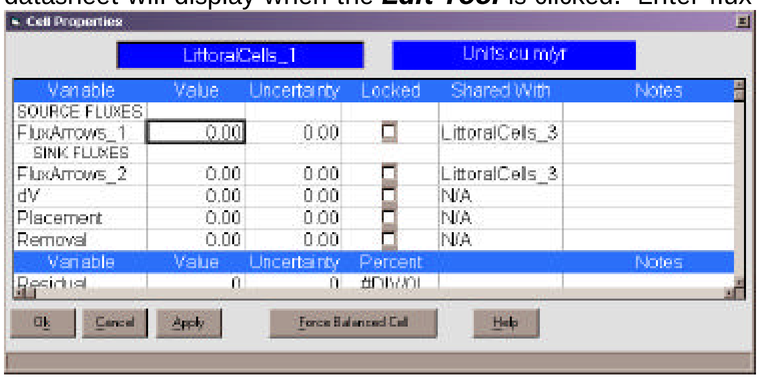


4. Open the ***attribute table*** of the Flux Layer.
5. View only the selected records by clicking on the ***Selected*** button.
6. Right-click on the EASTALL Column, select ***Statistics***.
7. Find the Mean value. This value will be used as the Easterly transport rate for the selected cell.
8. Right-click on the WESTALL Column, select ***Statistics***.
9. Find the Mean value. This value will be used as the Westerly transport rate for the selected cell.

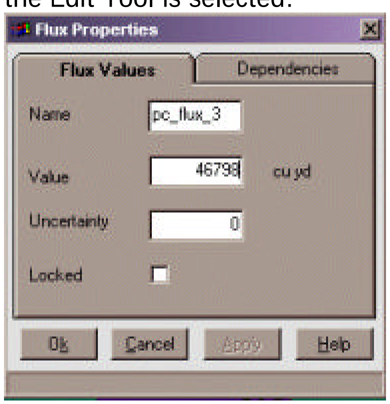
Enter Flux Values into the Sediment Budget

Data entry into the Sediment Budget Analysis System requires a custom extension. This extension is still in its beta release, but available for download on http://gis.sam.usace.army.mil. Please reference the SBAS-A technical note located at http://chl.wes.army.mil/library/publications/chetn/pdf/chetn-xiv7.pdf for full instructions on implementing SBAS-A for your Coastal GIS environment.

1. Having an ***Alternative*** already created, flux values can be entered into the data entry module.
2. Using the ***Cell/Flux Edit*** tool, select the desired flux arrow.
3. The selected layer in the Table of Contents and the feature selection of this layer determine the values to be edited when the SBAS-A ***Edit Tool*** is selected
4. If a cell layer is selected in the Table of Contents and has a littoral cell selection the following datasheet will display when the ***Edit Tool*** is clicked. Enter flux values in the appropriate cell.



5. If the flux layer is the selected layer in the Table of Contents, this data entry screen will appear when the Edit Tool is selected:



6. Both options allow the transport rate value to be added into the sediment budget.

the sources and sinks (transport rate values) to the control volume, respectively, dV is the net change in volume within the cell, P (Placement) and R (Removal) are the amounts of material placed in and removed from the cell, respectively. The SBAS-A extension automatically calculates the Residual for each cell each time cell and/or flux values are updated.

This process of creating cell and flux areas and calculating the residual allows a regional budget to develop. Once a budget is established, it can be used as the baseline for scenarios. A GIS provides a data repository and the tools available to create and calculate values necessary to populate a sediment budget.